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ZOOLOGY IN THE HIGH SCHOOL.[1]

BY CLARENCE M. WEED.

I do not see how the program recommended by the Natural History Conference of the Committee of Ten[2] can escape the charge of being inadequate and one-sided. According to it, eight years of study of at least two periods each week are to be devoted to plants before the high school is reached. This study includes not only the various parts and functions of the higher plants, their classification and life-histories, but the lower plants as well. Then in the high school five exercises a week for one school year are to be devoted to what can be considered only as a systematic review of knowledge already acquired. In all the twelve years of school life no provision is made for the study of animals, except a brief term of physiology, unless the advice of the conference is ignored and zoology is substituted for botany in the high school course. Truly it would appear that the much abused term—natural history—is to be restricted once more and become a synonym of botany. That the Conference did not intend to restrict the nature study of the lower schools to plants is abundantly shown by their answers to the questions submitted by the Committee of Ten, in which they distinctly recommend the study of both plants and animals for these grades.

The Conference "agreed that the year of study in natural history, recommended as a minimum for the high school, should be a consecutive year of daily recitations or laboratory work, and it is better to have the year's work devoted to one subject, either botany or zoology, than to have it divided between the two." Two years have passed since this opinion was promulgated, and while it may have represented the best educational ideas concerning the study of biology then, there is abundant evidence to show that it does not to-day. For there are many indications that biological teachers are accepting and adopting the dictum long since enunciated by Huxley that " the study of living bodies is really one discipline, which is divided into zoology and botany simply as a matter of convenience." Nothing shows this more clearly than the general adoption of such books as Huxley & Martin's Course of Elementary Instruction in Practical Biology, Parker's Lessons in Elementary Biology, Dodge's Introduction to Elementary Practical Biology, and Boyer's Laboratory Manual in Elementary Biology. These books are designed for use in the high schools and colleges, and unquestionably represent the consensus of opinion among the most successful biological teachers. They show that the study of living things can easily be carried on in a consecutive course in which the student may obtain a basis of sound biological knowledge concerning the organisms on both sides of the imaginary fence which separates the plant and animal world. I doubt if any fair-minded zoologist would think of insisting on confining the biological training of high school students to animals, for it would be a one-sided and inadequate training introducing the pupil to one phase of nature when he is entitled to an introduction to both. No more should the botanist claim an exclusive privilege in this respect.

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[1] From a paper read before a High School Teachers' Institute, Concord, N. H., Sept. 21, 1894.

[2] Rept. of Committe on Secondary School Studies, pp. 138–158., U. S. Bereau of Education.

The reasons given by the Conference report for choosing botany instead of zoology are three, viz.: (1) " Because the materials for the study of that subject are probably more easily obtained than those for the study of zoology; (2) Because the study of plants is more attractive to the average pupil; and (3) Because, in the study of animals, many prejudices or aversions have to be overcome." Obviously, these last two causes should be considered as one, the explanation of the greater attractiveness of plants must largely be found in the prejudices and aversions to animals. My own experience in teaching both subjects leads to the opinion that there is little weight to be given the argument on either side: some students prefer one subject and some the other, but the greatest enthusiasm is always aroused by the study of animals like Vorticella, whose life processes are watched in the field of the microscope. As to the first reason, the probable greater ease of procuring botanical material, the probability was not justified by the recent experience of Mr. C. H. Clark and myself at the New Hampshire College Summer School of Biology. We there went over, with nearly twenty teacher-students, the work in botany and zoology recommended in the programs of the Natural History Conference Committee, the afternoon sessions being devoted to botanical instruction by Mr. Clark, and the morning sessions to zoological instruction by myself. We both spent much of our spare time foraging for supplies, but I think Mr. Clark had the more difficult task of the two. Evidently these reasons are open to question, and, in any event, as mere reasons of expediency, they should give way to the larger considerations involved in other phases of the subject.

The limits of time forbid present discussion of the many claims of biology as a whole upon modern education, but I may say in passing that one of the most important of these claims is to be found in the relations of biological science to the philosophical problems of the day. Our philosophy is so permeated with the evolutionary phraseology that a knowledge of biological terms and processes is essential to the daily reading of an intelligent man. Such knowledge cannot be adequately obtained from the study of either plants or animals alone.

I believe that the position of a large proportion of biological teachers in America concerning biology in the high schools may fairly be represented by the following propositions: (1) That biology should be taught rather than either botany or zoology alone; (2) That the course should cover two years of at least three periods a week if possible, if not, that it cover as much time as can be spared to it, the minimum being one year; (3) That in general the time should be about equally divided between animals and plants, and that the study of the latter should come first, although some simple animal cells may well be studied at the start in connection with the lowest plants; (4) That the instruction should be given by means of the laboratory method of individual study of organic types, beginning with the lower forms and proceeding upward in the scale of life; (5) That the methods employed should aim to develop the faculties of the student as well as to add to his store of knowledge—should be educative as well as instructive; and (6) That the laboratory work should be supplemented to as great an extent as possible by field excursions and outside reading.

It is scarcely necessary at this time to emphasize the importance of the laboratory method of studying biology. It is the only possible way; and if it cannot be adopted the boys had better be turned out in the woods to study nature first hand there. They will thus gain more useful knowledge and experience than they possibly could from the old-fashion textbook of zoology in which the student was introduced through a dead language to a much deader world. The equipment of a biological laboratory need not be very expensive. The essential furniture will consist of low simply-constructed tables with accompanying chairs, shelf-room and window-space. Each student should be provided with a compound microscope which can be purchased for $17.00, and a few simple accessories. Glass jars of some form—nests of beakers of larger sizes are excellent—should be provided for aquaria, and some simple reagents and dissecting dishes are necessary.

The logical method of commencing the study of zoology unquestionably is to study the lowest forms first and proceed in natural sequence to the higher ones. The student thus acquires a philosophic view of the animal kingdom and of the method of its development. He studies first the cell in the manifold modifications which it assumes in the one-celled animals; then he sees cells remaining connected superficially to form the simplest metazoa, and finally studies their myriad combinations in the higher animals. He proceeds from the simple to the complex—studies the materials of construction before studying the completed structure. The chief objection that has been raised to this method is that the student is required to begin the subject with high powers of the microscope —an instrument with which he may not be familiar—and that by means of it he is suddenly introduced to new and strange forms of life. This objection has been urged with force by the master-teacher of modern biology, Professor Huxley, who, in the revised edition of his Course in Practical Biology, begins with the frog and works downward. That the experience of American teachers does not lead them to attach so much importance to the objection is shown by the fact that all of the authors of our best laboratory manuals—such as those of Dodge, Bumpus, Brooks and Boyer—have adopted the method of proceeding from below upward, and I think the practice of a majority of biological teachers points in the same direction. Possibly the aptness of American boys and girls in mastering such details as those of microscopic technique may account for the difference in the practice.

A serious objection to beginning the study of zoology with the frog or any higher animal is that it involves putting the student to the work of dissection before his interest is aroused. To many boys and more girls this is sufficient to give them a dislike to the whole subject. But if they first study living animals by watching their movements beneath the microscope, their interest can be so aroused that they can be led to simple dissections without difficulty. Many of them, indeed, will be so charmed with the work that they will echo the sentiment of the young lady at a leading New England college who is credited the enthusiastic remark that "Earthworms are perfectly lovely, especially the inside."

The teacher should adopt one of the newer laboratory guides, selecting the one that seems best adapted to the needs of the class and the time to be given to the subject, and having devoted a preliminary exercise to the use of the microscope, should start the students in individual studies of the types treated of in the guide. Abundance of material should be provided, and the students should be taught to rely upon their own resources to as great an extent as possible. At first they will need constant assistance, but later they will become more independent. Drawings and full notes are to be required.

An important part of the educational value of a laboratory course in biology depends on the requirements as to the student's notes. If one adopts the somewhat common practice of allowing the student to follow the laboratory guide in his notebook, often answering questions by number with a yes or no, the results will be far from satisfactory. In my own classes I have adopted the method of writing upon the blackboard a definite subject, *e. g.*, "A Description of the Structure and Biology of the Amoeba," upon which I require an original essay embodying the results of the student's observations, and such additional explanations as I have given the class at the time the animal was studied. These essays are written upon one side of the letter size paper that goes between clip binders. The drawings are incorporated in the proper places with explanations beneath, the aim being to make all as clear and concise as it should be in a book. These essays are submitted once a week, and if not satisfactory are rewritten. I hope soon to arrange a coöperation with the English department so that the essays may count as English exercises and be reviewed from the rhetorical point of view. Very decided progress has resulted from this method which seems to me the most desirable mode of note-keeping in such laboratory work.

But the ordinary laboratory manual by no means includes all of the "pedagogical contents of zoology." In general it confessedly covers with fair completeness only the morphological side of the subject and leaves almost or quite untouched important phases of the science which should never be ignored. To guide a student along the morphological road is unquestionably the safest and surest way of leading him to a sound basis of biological knowledge, but every opportunity should be taken to point out to him the objects of fascinating interest that are found beside the way. Failure to do this leads to the production of those near-sighted naturalists, who, in the expressive words of Professor Forbes, "must have nature boiled in corrosive sublimate solution and fried in paraffine and sliced by a microtome before they care for it." These are not the nature students the high schools wish to produce. Broadness, not narrowness, is here the aim; and the results in this respect will depend largely on the culture, enthusiasm and preparation of the teacher.

The most important general result to be taught in connection with morphology is that of physiology. So far as possible the study of function should coincide with the study of form. To a considerable extent the newer laboratory manuals provide for this, especially in the lower groups of animals. Emphasis should be laid upon this side of the subject, and explanations be reiterated until the student masters each detail. In the same connection—and here is one of the most important phases of zoology—the teacher should develop those laws of life which give to biology its greatest interest, such as the law of the physiological division of labor and of structural progress from simple to complex ; the relation of the one-celled animal to the multicellular one; the similarity of individual development to that of the group; the significance of the nucleus; the phases of reproduction; the facts of biogenesis and abiogenesis, of homogenesis and heterogenesis; the relations of parasitism to degeneration; the differences between plants and animals; the infinity of variations; the main facts of mimicry and protective resemblance; the effects of heredity and environment; the elements of natural selection, and an outline of the theory of organic evolution.

Perhaps you think this is laying too great a burden upon the teacher: it need not, for he may find an admirable, though concise discussion of these principles in Parker's Elementary Biology, and a more elaborate account of many of them in Lloyd Morgan's Animal Life. He should also have at hand for familiar reference Wallace's Darwinism, Poulton's Colors of Animals, Beddard's Animal Coloration, Rolleston's Forms of Animal Life, the Standard Natural History, the important zoological text-books, and as many other similar works as possible.

Perhaps the next most essential feature of the zoological course is a knowledge of the main outlines of animal classification. Not many years ago zöology was taught as if it consisted only of classification, and the inevitable reaction has gone so far that at present there is a tendency to ignore it altogether. This, however, is to be deplored. Classification is an essential feature of the science and should receive due consideration. Here the safest guide for the American teacher is the Standard Natural History which should be in every school library as a work of reference.

Much can be done in arousing the student's interest by means of field excursions and outside reading. These excursions should be taken as frequently as they conveniently can be, and be under the personal supervision of the instructor. Inland schools should plan, if possible, at least one trip to the seaside, choosing a time when the tide will be out during the visit, where crabs, sponges, starfishes, sea-urchins and anemones may be studied as well as sea-lettuce, rock-weeds and many other forms of plant and animal life.

The amount of collateral reading that may be done will vary with the conditions of the school and the interests of the individual student. Biology opens to one an enormous field of literature of fascinating interest in which the teacher should always be browsing; and if wise he will lead his flocks to the feet of the master-minds who have ever found joy and inspiration in the green pastures and beside the still waters, where dear old Mother Nature is always ready to receive our worship and breathe a benediction upon our holiest aspirations.

New Hampshire College, September, 1894.